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4401 Great America Parkway
Santa Clara, CA 95054

Installation and Networking Guidelines for Optical Routing

NORTEL NETWORKS™

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Preface

Nortel Networks* optical routing system supports high-speed data communications in metropolitan area networks (MANs) by:

- Connecting Gigabit Ethernet ports with fiber optic networks.
- Combining multiple wavelengths on a single fiber to expand available bandwidth.

The system components include:

Component	**Function**
CWDM Gigabit interface converters (GBICs)	Convert signals in a switch to laser light for connection to a fiber optic network.
Passive optical multiplexing devices	Combine laser light signals received from GBICs onto a single fiber for transport to the destination. Separates the wavelengths at the destination and routes them onto different fibers which terminate on separate GBICs.
Passive optical shelf	Houses the multiplexers.

This book contains the following topics:

Before you begin

This guide is intended for network administrators who have the following background:

- Basic knowledge of networks, and network hardware
- Familiarity with networking concepts and terminology
- Familiarity with Ethernet network administration and Fiber Channel networking

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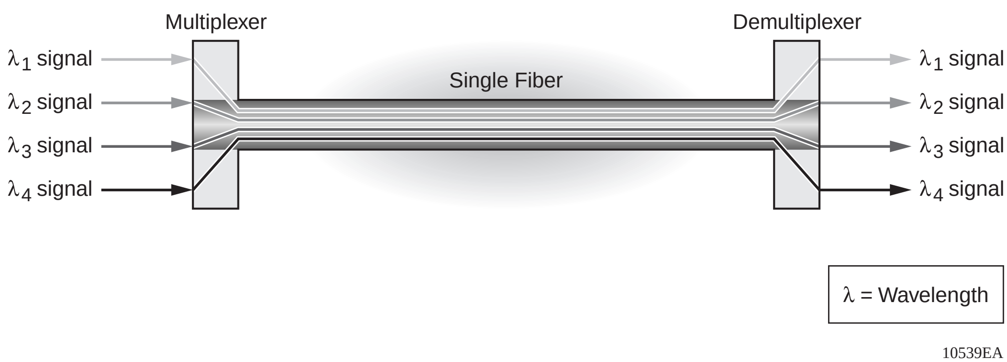
Chapter 1
Describing the optical routing system

Nortel Networks* optical routing system uses coarse wavelength division multiplexing (CWDM) in a grid of eight optical wavelengths. CWDM Gigabit Interface Converters (GBICs) in the switch transmit optical signals from Gigabit Ethernet ports to multiplexers in a passive optical shelf. Multiplexers combine multiple wavelengths traveling on different fibers onto a single fiber (Figure 1). At the receiver end of the link, demultiplexers separate the wavelengths again and route them onto different fibers which terminate on separate CWDM GBICs at the destination. The system supports both ring and point-to-point configurations.

Figure 1 Wavelength division multiplexing



This chapter includes the following topics:

Parts of the optical routing system

The optical routing system includes the following parts:

- Gigabit interface converters (CWDM GBICs)
- Optical add/drop multiplexers (CWDM OADMs)
- Optical multiplexer/demultiplexers (CWDM OMUXs)
- Optical shelf to house the multiplexers

Table 1 shows the parts of the optical routing system, and the color matching used to distinguish the eight wavelengths.

Table 1 Parts of the optical routing system

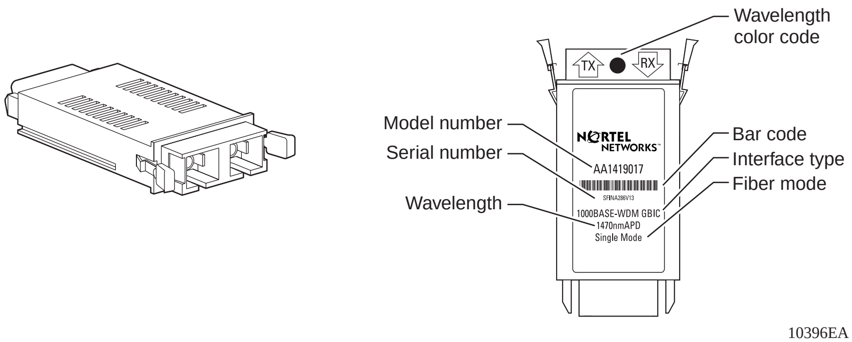
<table>
<tr><th rowspan="2">Wavelength (longwave)</th><th rowspan="2">Color code</th><th rowspan="2">GBIC part number</th><th colspan="3">Multiplexer part number</th><th rowspan="2">Optical shelf part number</th></tr>
<tr><th>OADM</th><th>OMUX-4</th><th>OMUX-8</th></tr>
<tr><td>1470 nm</td><td>Gray</td><td>AA1419017</td><td>AA1402002</td><td></td><td rowspan="8">AA1402010</td><td rowspan="8">AA1402001</td></tr>
<tr><td>1490 nm</td><td>Violet</td><td>AA1419018</td><td>AA1402003</td><td>AA1402009</td></tr>
<tr><td>1510 nm</td><td>Blue</td><td>AA1419019</td><td>AA1402004</td><td></td></tr>
<tr><td>1530 nm</td><td>Green</td><td>AA1419020</td><td>AA1402005</td><td>AA1402009</td></tr>
<tr><td>1550 nm</td><td>Yellow</td><td>AA1419021</td><td>AA1402006</td><td></td></tr>
<tr><td>1570 nm</td><td>Orange</td><td>AA1419022</td><td>AA1402007</td><td>AA1402009</td></tr>
<tr><td>1590 nm</td><td>Red</td><td>AA1419023</td><td>AA1402008</td><td></td></tr>
<tr><td>1610 nm</td><td>Brown</td><td>AA1419024</td><td>AA1402011</td><td>AA1402009</td></tr>
</table>

Gigabit interface converter description

Nortel Networks* coarse wavelength division multiplexed Gigabit Interface Converters (Figure 2) convert signals in a switch to laser light for connection to a fiber optic network. A CWDM GBIC transmits and receives optical signals at one of eight specific wavelengths.

Nortel CWDM GBICs use Avalanche Photodiode (APD) technology to improve transmission distance and optical link budget.

Figure 2 CWDM GBIC transceiver and label



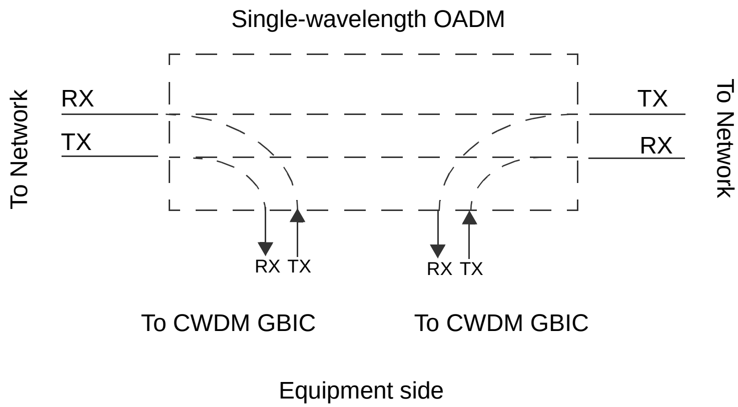
For more information about CWDM GBICs, including specifications, see *Installing CWDM Gigabit Interface Converters,* part number 212256-B.

Optical add drop multiplexer description

The passive CWDM optical add drop multiplexer (CWDM OADM) sends and receives signals to/from CWDM GBICs installed in the switch. It is set to a specific wavelength that matches the wavelength of the CWDM GBIC. It adds or drops this specific wavelength from the optical fiber and allows all other wavelengths to pass straight through. The Nortel Networks CWDM OADM supports two separate fiber pathways traveling in opposite directions (east and west) so that the network remains viable even if the fiber is broken at one point on the ring.

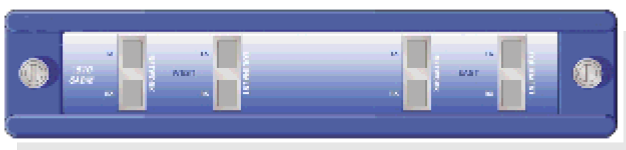
Figure 3 shows the single wavelength CWDM OADM network and equipment side connections.

Figure 3 CWDM OADM network and equipment side connections



The CWDM OADM (Figure 4) is installed in a 19-inch, rack-mounted 1RU optical shelf (Figure 15).

Figure 4 CWDM OADM Front Panel



For information about installing a CWDM OADM, see "Inserting a CWDM OADM or a CWDM OMUX" on page 38. For specifications, see "CWDM OADM specifications" on page 45.

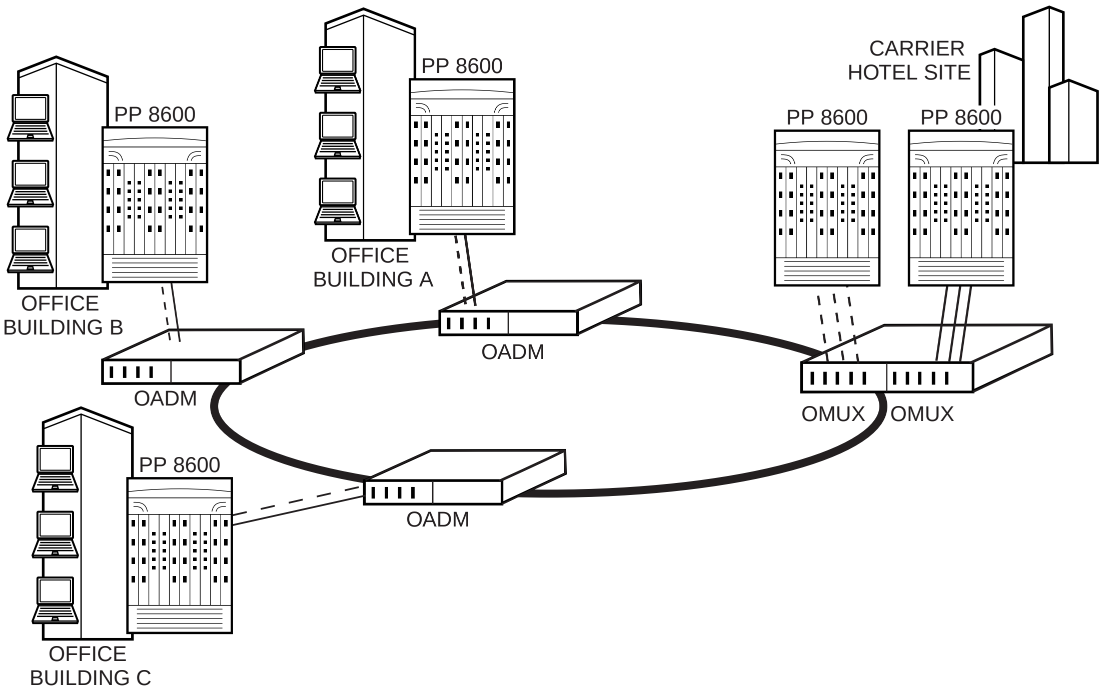
Network add/drop ring application

The CWDM OADM pulls off a specific wavelength from an optical ring and passes it to a CWDM GBIC of the same wavelength in the switch, leaving all other wavelengths on the ring undisturbed. CWDM OADMs are set to one of eight supported wavelengths (Table 1).

Note: The wavelength of the CWDM OADM and the corresponding CWDM GBIC must match (see Table 1).

Figure 5 shows an example of two separate fiber paths in a ring configuration traveling in opposite or east/west directions into the network.

Figure 5 CWDM OADM ring configuration example



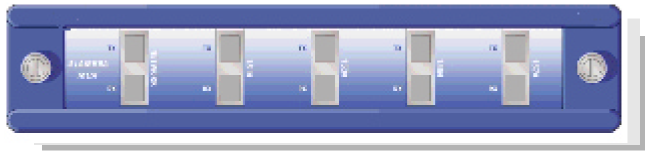
For information on calculating network transmission distance, see Chapter 2, “Calculating transmission distance,” on page 27.

Optical multiplexer/demultiplexer description

The passive CWDM OMUX sends and receives signals to/from CWDM GBIC transceivers installed in the switch. It multiplexes and demultiplexes four or eight CWDM wavelengths from a two-fiber (east and west) circuit. It allows you to create uni-directional network traffic rings or point-to-point links.

The CWDM OMUX (Figure 6) is installed in a 19-inch, rack-mounted 1RU optical shelf (Figure 15).

Figure 6 Four-channel CWDM OMUX front panel

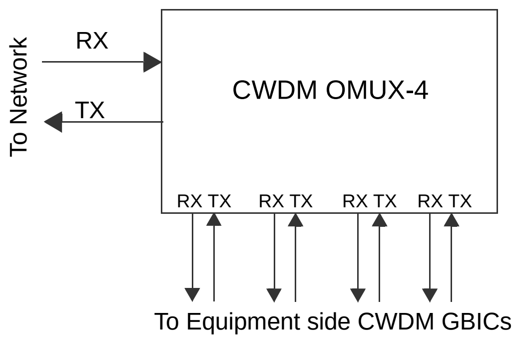


Connectors with color-coded labels (Table 1) simplify connection to color-coded CWDM GBICs in the switch.

CWDM OMUX-4

Figure 7 shows the CWDM OMUX-4 version, with four CWDM GBIC equipment side connections.

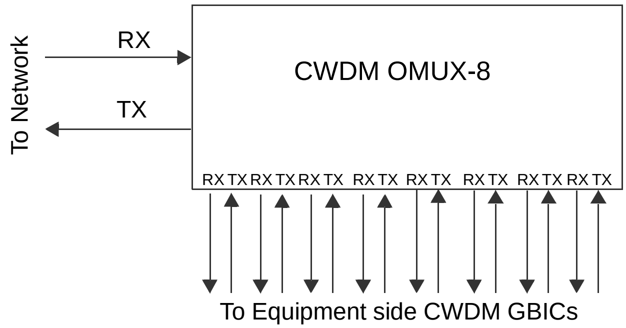
Figure 7 CWDM OMUX-4 network and equipment side connections



CWDM OMUX-8

Figure 8 shows the CWDM OMUX-8 version, with eight CWDM GBIC equipment side connections.

Figure 8 CWDM OMUX-8 network and equipment side connections



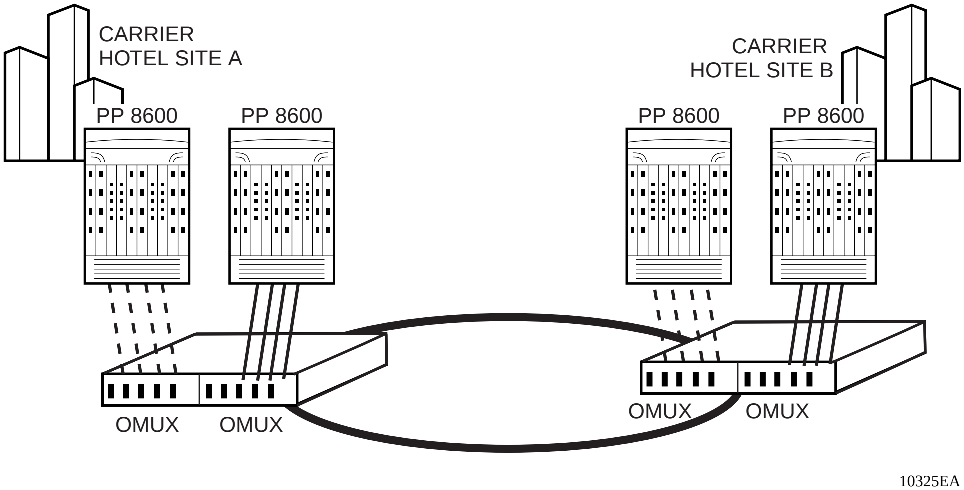
For information about installing a CWDM OMUX, see "Inserting a CWDM OADM or a CWDM OMUX" on page 38. For specifications, see "CWDM OMUX specifications" on page 47.

CWDM OMUX in a point-to-point application

Point-to-Point (PTP) optical networks carry data directly between two end points without branching out to other points or nodes. PTP connections (Figure 9) are made between mux/demuxs at each end. PTP connections transport many gigabits of data from one location to another, such as linking two data centers to become one virtual site, mirroring two sites for disaster recovery, or providing a large amount of bandwidth between two buildings. The key advantage of a PTP topology is the ability to deliver maximum bandwidth over a minimum amount of fiber.

Each CWDM OMUX supports one network backbone connection and four or eight connections to CWDM GBICs in the switch. Typically, two CWDM OMUXs are installed in a chassis. The CWDM OMUX on the left is called the east path and the CWDM OMUX on the right is called the west path.

Figure 9 CWDM OMUX point-to-point configuration example

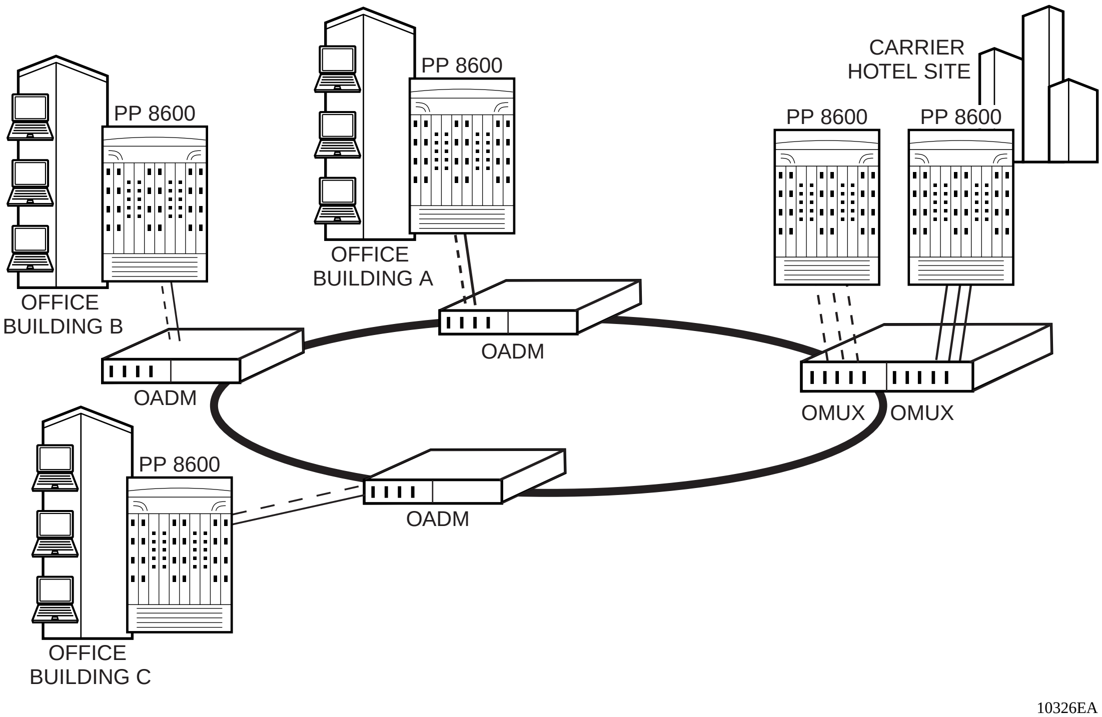


For information about calculating network transmission distance, see Chapter 2, “Calculating transmission distance,” on page 27.

CWDM OMUX in a ring application

CWDM OMUXs are also used as the hub site in CWDM OMUX-based ring applications (Figure 10). Two CWDM OMUXs are installed in the optical shelf at the central site to create an east and a west fiber path. The CWDM OMUX on the left is typically called the east path and the one on the right is called the west path. This way the east CWDM OMUX terminates all the traffic from the east equipment port of each OADM on the ring and the west CWDM OMUX terminates all of the traffic from the west equipment port of each OADM on the ring. In this configuration the network remains viable even if the fiber is broken at any point on the ring.

Figure 10 CWDM OMUX ring configuration example



For information about calculating network transmission distance, see Chapter 2, "Calculating transmission distance," on page 27.

Chapter 2
Calculating transmission distance

This chapter will help you determine the maximum transmission distance for your CWDM network configuration.

This chapter includes the following topics:

About transmission distance and optical link budget

By calculating the optical link budget, you can determine a link's transmission distance, or the amount of usable signal strength between the point where it originates and the point where it terminates. The loss budget, or optical link budget, is the amount of optical power launched into a system that is expected to be lost through various mechanisms acting on the system, such as the absorption of light by molecules in an optical fiber. Factors that affect transmission distance include:

- fiber optic cable attenuation (typically 0.25 dB - 0.3 dB per kilometer)
- network devices the signal passes through
- connectors
- repair margin (user-determined)

Note: Insertion loss budget values for the optical routing system CWDM OADM and CWDM OMUX include connector loss.

How to calculate expected loss budget

To calculate the expected loss budget for a proposed network configuration:

1. Identify all points where signal strength will be lost.
2. Calculate the expected loss for each point.
3. Add the expected losses together.

How to calculate maximum transmission distance

The examples in this chapter use the following assumptions and procedure for calculating the maximum transmission distances for networks with CWDM GBICs, CWDM OADMs, and CWDM OMUXs.

Assumptions

The examples assume use of the values and information listed in Table 2.

Table 2 Assumptions used in calculating maximum transmission distance

Item	**Assumption**
Cable	Single mode fiber optic cable (SMF)
Repair margin	0[1]
Maximum link budget	30 dB[2]
System margin	3 dB (allowance for misc. network loss)
Fiber attenuation	.25 dB per kilometer
Operating temperature	0 - 40°C (32 - 104°F)
CWDM OADM expected loss[3]	Use of "CWDM OADM specifications" on page 45
CWDM OMUX expected loss[3]	Use of "CWDM OMUX specifications" on page 47

1 Use your organization's expected repair margin for percentage of the total fiber plant loss for each site-to-site fiber span.

2 From specifications in *Installing CWDM Gigabit Interface Converters*, part number 212256-B

3 Multiplexer loss values include connector loss.

Procedure

To calculate the maximum transmission distance for a proposed network configuration:

1. Identify all points where signal strength will be lost.
2. Calculate the expected loss for each point.
3. Find total passive loss by adding the expected losses together.
4. Find remaining signal strength by subtracting passive loss, and system margin from total system budget.
5. Find maximum transmission distance by dividing remaining signal strength by expected fiber attenuation/km.

Point-to-point transmission distance

The following factors affect signal strength, and determine point-to-point link budget and maximum transmission distance for the network in Figure 11:

- CWDM OMUX mux loss
- CWDM OMUX demux loss
- Fiber attenuation

The Ethernet switch host does not have to be near the CWDM OMUX, and the CWDM OMUX does not regenerate signal. Therefore, maximum transmission distance is from GBIC to GBIC.

Figure 11 Point-to-point network configuration example

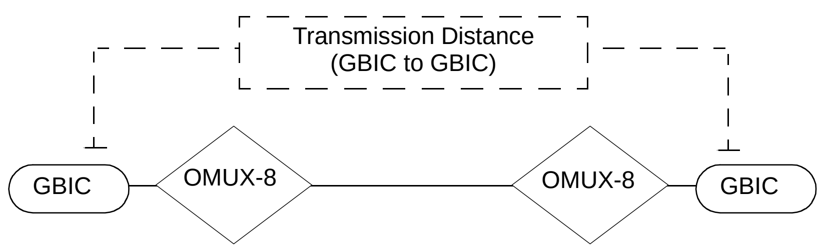


Table 3 shows typical loss values that can be used to calculate the transmission distance for the point-to-point network in Figure 11.

Table 3 Point-to-point signal loss values

Signal loss element	value (dB)
Loss budget	30 dB
CWDM OMUX-8 mux loss	3.5 dB
CWDM OMUX-8 demux loss	4.5 dB
System margin	3 dB
Fiber attenuation	.25 dB per km

Table 4 shows calculations used to determine maximum transmission distance for the point-to-point network example in Figure 11.

Table 4 Point-to-point maximum transmission distance calculations

Result	Calculation
Passive loss	mux loss + demux loss
Implied fiber loss	loss budget – passive loss – system margin
Maximum transmission distance	implied fiber loss ÷ attenuation per kilometer

Transmission distance calculation for the point-to-point network example in Figure 11:

- 3.5 dB + 4.5 dB= 8.0 dB Passive Loss
- 30 dB –8 dB –3 dB= 19 dB Implied Fiber Loss
- 19 dB ÷ .25 dB= 76 km Maximum Transmission Distance

Mesh ring transmission distance

The transmission distance calculation for the mesh ring configuration in Figure 12 is similar to that of the point-to-point configuration with some additional loss generated in the passthrough of intermediate CWDM OADM nodes.

As it passes from point A to point B (the most remote points in the mesh ring network example in Figure 12), the signal is expected to lose strength in the fiber optic cable, and in each connection between the individual CWDM OADMs and CWDM GBICs.

The following factors determine mesh ring link budget and transmission distance for the network in Figure 12:

- CWDM OADM insertion add loss
- CWDM OADM insertion drop loss
- Passthrough insertion loss at intermediate nodes
- Fiber attenuation of 0.25 dB per kilometer

The Ethernet switch host does not have to be near the CWDM OADM, and the CWDM OADM does not regenerate signal. Therefore, maximum transmission distance is from GBIC to GBIC.

The number of OADMs supported is based on loss budget calculations.

Figure 12 Mesh ring network configuration

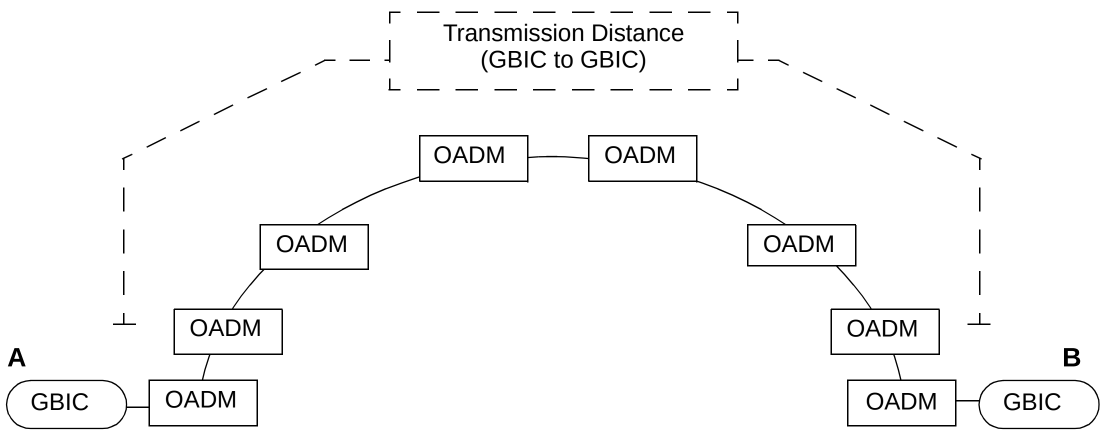


Table 5 shows typical loss values that can be used to calculate the transmission distance for the mesh ring network example in Figure 12.

Table 5 Mesh ring signal loss values

Signal loss element	value
Loss budget	30 dB
CWDM OADM insertion add loss	1.9 dB
CWDM OADM insertion passthrough loss	2.0 dB
CWDM OADM insertion drop loss	2.3 dB
System margin	3 dB
Fiber attenuation	.25 dB per km

Table 6 shows the calculations used to determine maximum transmission distance for the mesh ring network example in Figure 12.

Table 6 Mesh ring maximum transmission distance calculations

Result	Calculation
Passthrough nodes	nodes – 2
Passive loss	OADM add + OADM drop + (passthrough nodes × OADM passthrough loss)
Implied fiber loss	loss budget – passive loss – system margin
Maximum transmission distance	implied fiber loss ÷ attenuation per kilometer

Transmission distance calculation for the mesh ring network example in Figure 12:

- 8 nodes – 2 = 6 Passthrough nodes
- 1.9 dB + 2.3 dB + (6 nodes × 2.0 dB) = 16.2 dB Passive Loss
- 30 dB – 16.2 dB – 3 dB = 10.8 dB Implied Fiber Loss
- 10.8 dB ÷ .25 dB = 43.2 km Maximum Transmission Distance

Hub and spoke transmission distance

Hub and Spoke topologies are the most complex. The characteristics of all components designed into the network must be considered in calculating transmission distance. The following factors determine maximum transmission distance for the hub and spoke configuration in Figure 13:

- CWDM OADM insertion add loss
- CWDM OADM insertion drop loss
- Passthrough insertion loss for intermediate nodes
- Fiber attenuation of 0.25 per kilometer

The Ethernet switch host does not have to be near the CWDM OADM, and the CWDM OADM does not regenerate signal. Therefore, maximum transmission distance is from GBIC to GBIC.

As the signal in Figure 13 passes from point A to point B (the most remote points in the hub and spoke), it is expected to lose strength in the fiber optic cable, and in each connection between the individual CWDM OADMs, the CWDM OMUX-8, and the CWDM GBICs. The number of OADMs that can be supported is based on the loss budget calculations.

Figure 13 Hub and spoke network configuration

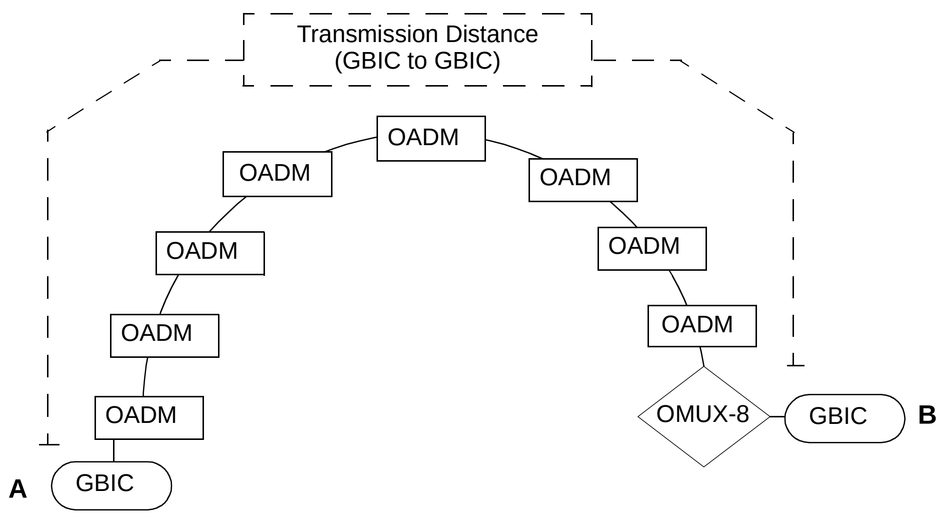


Table 7 shows typical loss values that can be used to calculate the transmission distance for the hub and spoke network in Figure 13.

Table 7 Hub and spoke signal loss values

Signal loss element	value
Loss budget	30 dB
CWDM OADM insertion add loss	1.9 dB
CWDM OADM passthrough loss	2.0 dB
CWDM OMUX8 demux loss	4.5 dB
System margin	3 dB
Fiber attenuation	.25 dB per km

Table 8 shows the calculations used to determine maximum transmission distance for the hub and spoke network in Figure 13.

Table 8 Hub and spoke maximum transmission distance calculations

Result	Calculation
Passthrough nodes	the number of OADMs between add OADM and OMUX
Passive loss	OADM add + OMUX8 demux + (passthrough nodes × OADM passthrough loss)
Implied fiber loss	loss budget – passive loss – system margin
Maximum transmission distance	implied fiber loss ÷ attenuation per kilometer

Transmission distance calculation for the hub and spoke network example in Figure 13:

- 7 Passthrough nodes
- $1.9 \text{ dB} + 4.5 \text{ dB} + (7 \times 2.0) = 20.4 \text{ dB}$ Passive Loss
- $30 \text{ dB} - 20.4 \text{ dB} - 3 \text{ dB} = 6.6 \text{ dB}$ Implied Fiber Loss
- $6.6 \text{ dB} \div .25 \text{ dB} = 26.4 \text{ km}$ Maximum Transmission Distance

Chapter 3
Installing the shelf, OADM, and OMUX

The shelf and multiplexers are passive equipment and require no power or electronic This chapter describes how to install optical routing components, and includes the following topics.

- "Preparing for installation" next
- "Installing the shelf" on page 37
- "Inserting a CWDM OADM or a CWDM OMUX" on page 38
- "Removing a CWDM OADM or a CWDM OMUX" on page 44
- "Cabling a CWDM OADM or a CWDM OMUX" on page 39

Preparing for installation

Before installing the optical routing system, observe the following:

- "Exceeding class 1 power level warning" next
- "Environmental and physical requirements" on page 36
- "Electrostatic discharge" on page 36
- "Handling and cleaning fiber optic equipment" on page 49

Exceeding class 1 power level warning

Muxing together several CWDM GBICs can produce a radiant power level in the fiber which exceeds the class 1 laser Limit. The warning in Figure 14 appears on the CWDM OMUX.

Figure 14 Class 1M laser warning

LASER RADIATION
DO NOT VIEW DIRECTLY WITH OPTICAL
INSTRUMENTS (MAGNIFIERS)
CLASS 1M LASER PRODUCT
TOTAL RADIANT POWER LEVEL 30 MILLIWATTS
WAVELENGTH RANGE 1450 TO 1650 NM

Warning: Never look directly at the output of a fiber which contains muxed CWDM GBICs, especially with a magnifier. Fiber optic equipment can emit laser light that can injure your eyes.

Environmental and physical requirements

The optical routing system is mounted in an optical shelf with connections at the front of the module. For user access to these connections, a minimum of 36 inches (90 cm) of clearance is required. Keep the area as dust-free as possible.

Caution: To minimize contamination, keep protective caps on all fiber optic connectors when not in use. For more information about handling fiber optic cables, see "Handling and cleaning fiber optic equipment" on page 49.

Electrostatic discharge

To prevent equipment damage, observe the following electrostatic discharge (ESD) precautions when handling or installing the components.

- Ground yourself and the equipment to an earth or building ground. Use a grounded workbench mat (or foam that dissipates static charge) and a grounding wrist strap. The wrist strap should touch the skin and be grounded through a one megohm resistor.
- Do not touch anyone who is not grounded.
- Leave all components in their ESD-safe packaging until installation, and use only a static-shielding bag for all storage, transport, and handling.

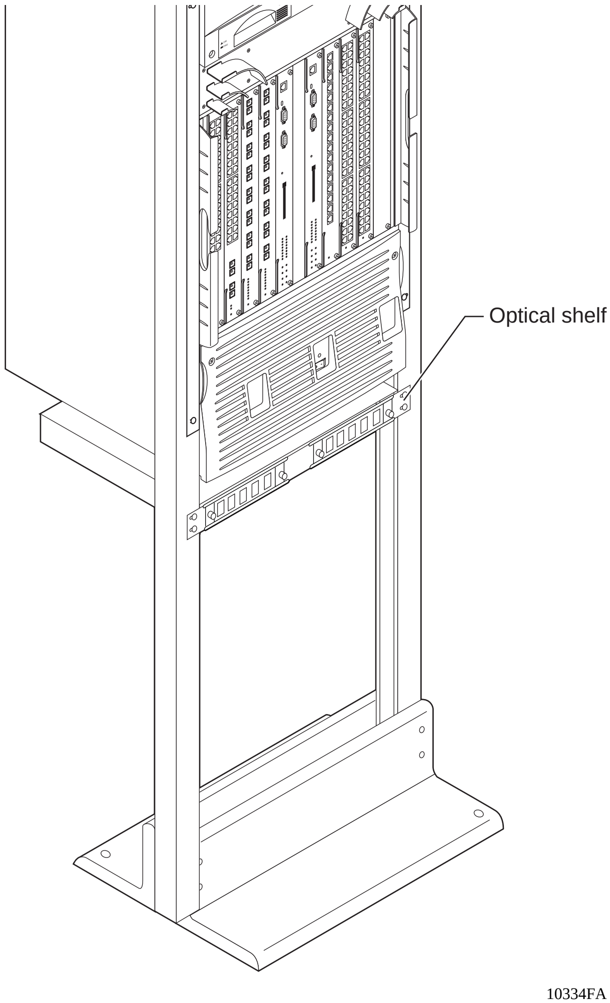
- Clear the area of synthetic materials such as polyester, plastic, vinyl, or styrofoam because these materials carry static electricity that damages the equipment.

Installing the shelf

To install the optical shelf (Figure 15) in a standard 19-inch equipment rack:

1. Support the chassis so that all of the mounting holes in the optical shelf are aligned with the corresponding holes in the rack.
2. Attach two rack mounting bolts to each side of the rack.
3. Tighten all of the bolts in rotation.

Figure 15 Shelf with plug-in module in 19-inch rack



Inserting a CWDM OADM or a CWDM OMUX

CWDM OADMs and CWDM OMUXs are passive devices that require no power for their operation. You can insert them in the optical shelf (Figure 15) and then connect them into your network.

To insert a CWDM OADM or a CWDM OMUX in the optical shelf:

1. Align the plug-in module with the optical shelf.
2. Gently push the plug-in module into the shelf cavity.
3. Tighten the captive screws.

   The module is installed. To cable equipment and network connections, see "Cabling a CWDM OADM or a CWDM OMUX" on page 39.

Cabling a CWDM OADM or a CWDM OMUX

This section includes the following cabling procedures:

- "Cabling a CWDM OADM" next
- "Cabling a four-channel CWDM OMUX" on page 41
- "Cabling an eight-channel CWDM OMUX" on page 42

Before you attach fiber optic cable to an optical routing device, review the following:

- "Handling and cleaning fiber optic equipment" on page 49
- Table 1, Parts of the optical routing system

Cabling a CWDM OADM

This section describes how to cable the following:

- CWDM GBIC to CWDM OADM (Figure 16)
- CWDM OADM to network backbone interfaces (Figure 16)

To connect the CWDM OADM plug-in module:

1. Make sure you have the correct CWDM GBIC for your network configuration by matching the color of the CWDM GBIC label to the color of the connector label on the OADM (see Table 1 on page 18).

2 Insert the wavelength-specific CWDM GBICs into their respective network device(s). To install a CWDM GBIC, see *Installing CWDM Gigabit Interface Converters*, part number 212256-B.

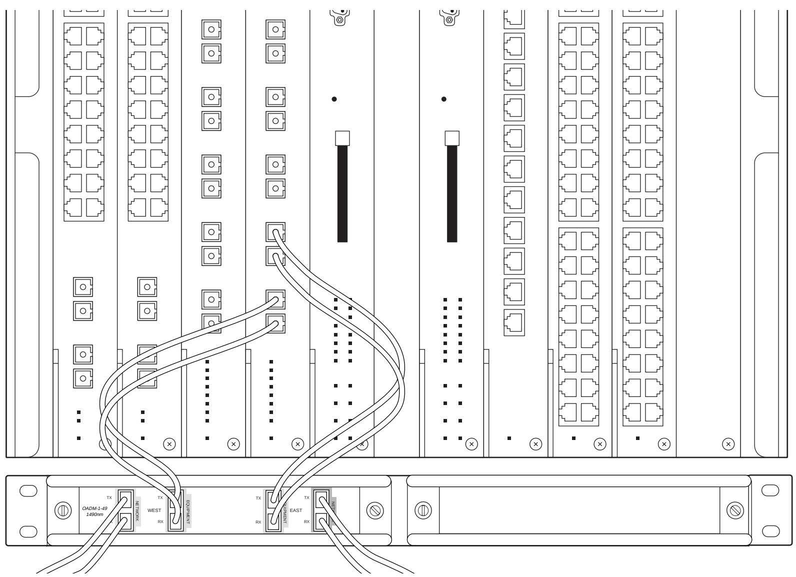
3 Clean all fiber optic connectors on the cabling (see "Handling and cleaning fiber optic equipment" on page 49).

4 Connect the fiber optic cables from the CWDM GBIC transmit (TX) and receive (RX) connectors to the OADM Equipment RX and TX equipment connectors (Figure 16).

5 Make the following network backbone connections (Figure 16):

- Connect the west network backbone fiber optic cable to the OADM west connector.
- Connect the east backbone fiber optic cable to the OADM east connector (Figure 16).

Figure 16 Cabling a CWDM OADM



Cabling a four-channel CWDM OMUX

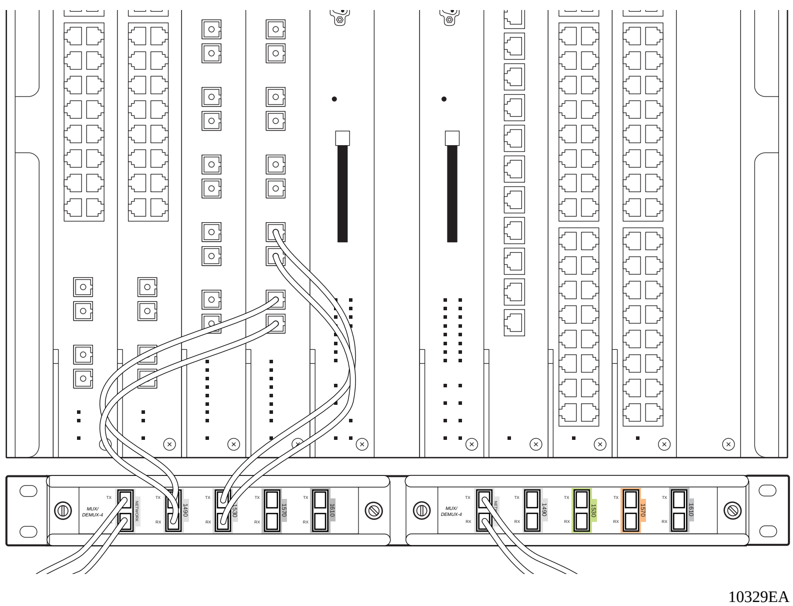
This section describes how to cable the following:

- CWDM GBIC to a CWDM OMUX-4 (Figure 17)
- CWDM OMUX-4 to west and east network backbone interfaces (Figure 17)

To connect fiber optic cables to a CWDM OMUX-4:

1. Insert the wavelength-specific CWDM GBICs into their respective network device(s). To install a CWDM GBIC, see *Installing CWDM Gigabit Interface Converters*, part number 212256-B.
2. Clean all fiber optic connectors on the cabling (see “Handling and cleaning fiber optic equipment” on page 49).
3. Connect the fiber optic cables from the CWDM GBIC TX and RX to the CWDM OMUX-4 Equipment RX and TX equipment connectors (Figure 17).

Figure 17 Cabling a CWDM OMUX-4



Note: The CWDM GBIC wavelength must match the CWDM OMUX-4 equipment connector wavelength.

The TX of one device must always connect to the RX of the next device.

4 Make the following network backbone connections (Figure 17):

- Connect the network backbone east fiber optic cables to the east (left) CWDM OMUX-4.
- Connect the network backbone west fiber optic cables to the west (right) CWDM OMUX-4.

Cabling an eight-channel CWDM OMUX

This section describes how to cable the following:

- CWDM GBIC to a CWDM OMUX-8 (Figure 18)
- CWDM OMUX-8 to network backbone interfaces (Figure 18)

Note: The CWDM OMUX-8 located on the left side of the chassis terminates the east network backbone connection. The CWDM OMUX-8 on the right side of the chassis terminates the west network backbone connection. See Figure 18.

To connect a CWDM OMUX-8:

1 Install the CWDM GBICs (wavelength specific) into the network device(s). To install a CWDM GBIC, see *Installing CWDM Gigabit Interface Converters*, part number 212256-B.

2 Clean all fiber optic connectors on the cabling (see “Handling and cleaning fiber optic equipment” on page 49).

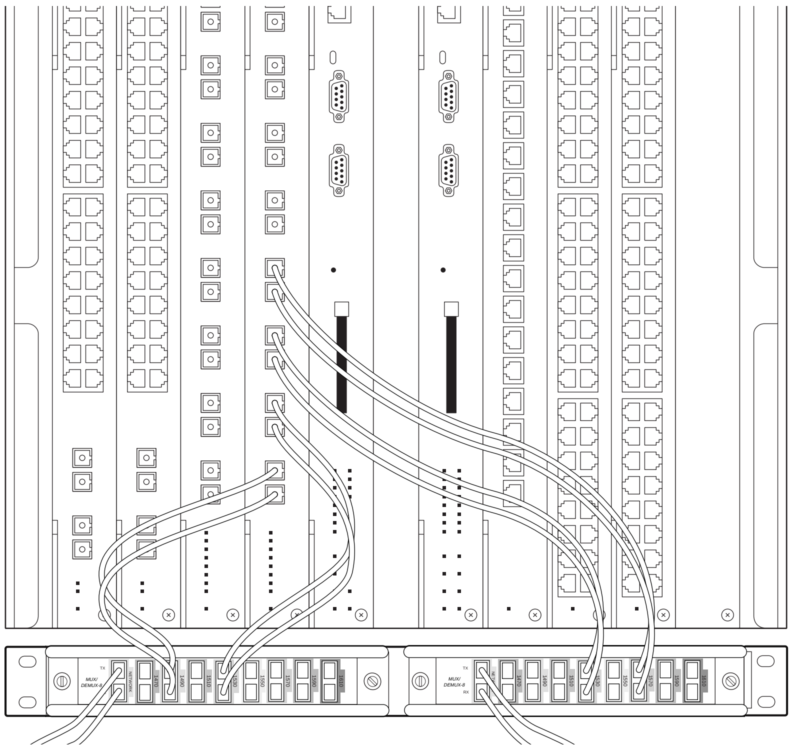
3 Connect the fiber optic cables from the CWDM GBIC TX and RX connectors to the CWDM OMUX-8 RX and TX connectors (Figure 18).

Note: The wavelength of the CWDM GBIC must match the wavelength of the CWDM OMUX-8 equipment connector.

4 Make the following network backbone connections (Figure 18):

- Connect the network backbone east fiber optic cables to the east (left) CWDM OMUX-8.
- Connect the network backbone west fiber optic cables to the west (right) CWDM OMUX-8.

Figure 18 Cabling an CWDM OMUX-8



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Removing a CWDM OADM or a CWDM OMUX

CWDM OADMs and CWDM OMUXs are passive devices that require no power for their operation. You can remove them from the optical shelf (Figure 15) after disconnecting them from your network.

To remove a CWDM OADM or a CWDM OMUX plug-in module from the optical shelf:

1. Disconnect the network cabling from the multiplexer.
2. Loosen the captive screws on both sides of the module.
3. To release the module, gently pull on both screws at the same time.
4. Slide the module out of the shelf.

Appendix A
CWDM OADM specifications

Table 9 CWDM OADM specifications

Item	Specification	
Physical Dimensions	Plug-in Module Size Rack Mount	8.35” x 1.7" x 10.4" 1RU
Connectors	Network Side Equipment Side	2 dual SC/PC 2 dual SC/PC
Cabling		SMF, 9 µm
Environment	Operating Storage	0 to 60^{0}C 40 to 85^{0}C
Wavelength Usage	Uni-directional	
Typical insertion loss*	TX Equipment to RX Network (add) RX Equipment to TX Network (drop) Passthrough (Network to Network)	1.2 dB 1.6 dB 1.5 dB
Maximum insertion loss*	TX Equipment to RX Network (add) RX Equipment to TX Network (drop) Passthrough (Network to Network)	1.9 dB 2.3 dB 2.0 dB
Sigma	TX Equipment to RX Network (add) RX Equipment to TX Network (drop) Passthrough (Network to Network)	.35 dB .35 dB .40 dB
Isolation	TX Equipment to RX Network (add) RX Equipment to TX Network (drop) Passthrough (Network to Network)	> 25 dB > 50 dB > 28 dB
Passband	Centerwavelength	+/- 5nm
Directivity		< 55 dB
Optical	Wavelengths†	1471 nm 1491 nm 1511 nm 1531 nm 1551 nm 1571 nm 1591 nm 1611 nm

* Multiplexer loss values include connector loss.

† There is a one nanometer offset between the stated wavelength for the CWDM GBICs and the CWDM OADMs due to a shift in the center wavelength of the CWDM GBIC as it reaches typical system operating temperature.

Appendix B
CWDM OMUX specifications

Table 10 CWDM OMUX specifications

Item	Specification		
Physical Dimensions	Plug-in Module Size Rack Mount	8.35” x 1.75" x 8.7" 1RU	
Connectors	 Network Side Equipment Side	**OMUX-4** 1 dual SC/PC 4 dual SC/PC	**OMUX-8** 1 dual SC/PC 8 dual SC/PC
Cabling		SMF, 9 µm	
Environment	Operating Storage	0 to 60ºC 40 to 85ºC	
Typical insertion loss*	 TX Equipment to RX Network (Mux) RX Equipment to TX Network (Demux)	**OMUX-4** 1.4 dB 2.4 dB	**OMUX-8** 2.5 dB 3.5 dB
Maximum insertion loss*	 TX Equipment to RX Network (Mux) RX Equipment to TX Network (Demux)	**OMUX-4** 2.2 dB 3.2 dB	**OMUX-8** 3.5 dB 4.5 dB
Sigma	 TX Equipment to RX Network (Mux) RX Equipment to TX Network (Demux)	**OMUX-4** 0.4 dB 0.4 dB	**OMUX-8** 0.5 dB 0.5 dB
Isolation	 Mux Demux	**OMUX-4** > 10 dB > 50 dB	**OMUX-8** > 10 dB > 50 dB
Directivity		< –55 dB	
Optical OMUX4	Wavelengths†	**OMUX-4** 1491 nm 1531 nm 1571 nm 1611 nm	**OMUX-8** 1471 nm 1491 nm 1511 nm 1531 nm 1551 nm 1571 nm 1591 nm 1611 nm

* Multiplexer loss values include connector loss.

† There is a one nanometer offset between the stated wavelength for the CWDM GBICs and the CWDM OADMs due to a shift in the center wavelength of the CWDM GBIC as it reaches typical system operating temperature.

Appendix C
Handling and cleaning fiber optic equipment

Precautions

Danger: Do not look into the end of fiber optic cable. The light source used in fiber optic cables can damage your eyes.

Warning: To prevent damage to the glass fiber, make sure you know how to handle fiber optic cable correctly.

Warning: Do not crush fiber optic cable. If fiber optic cable is in the same tray or duct with large, heavy electrical cables, it can be damaged by the weight of the electrical cable.

Although the glass optical path of fiber optic cable is protected with reinforcing material and plastic insulation, it is subject to damage. Use the following precautions to avoid damaging the glass fiber.

- Do not kink, knot, or vigorously flex the cable.
- Do not bend the cable to less than a 40 mm (1.5-inch) radius.
- Do not stand on fiber optic cable; and keep the cable off the floor.
- Do not pull fiber optic cable any harder than you would a cable containing copper wire of comparable size.
- Do not allow a static load of more than a few pounds on any section of the cable.
- Place protective caps on fiber optic connectors that are not in use.
- Store unused fiber optic patch cables in a cabinet, on a cable rack, or flat on a shelf.

Frequent overstressing of fiber optic cable causes progressive degeneration that leads to failure.

If you suspect damage to a fiber optic cable, either due to mishandling or an abnormally high error rate observed in one direction, reverse the cable pairs. If the high error rate appears in the other direction, replace the cable.

Tools and Materials

You need the following tools and materials to clean fiber optic connectors.

- Lint-free, non-abrasive wiping cloths
- Cotton swabs, with a tightly wrapped and talcum-free tip
- Optical-grade isopropyl alcohol (IPA)
- Canned compressed gas with extension tube

Warning: To prevent oil contamination of connectors, do not use commercial compressed air or house air in place of compressed gas.

Cleaning Fiber Optic Connectors

You must perform the following maintenance procedures to ensure that optical fiber assemblies function properly. To prevent them from collecting dust, make sure connectors are covered when not in use.

This section contains the following procedures for cleaning fiber optic assemblies:

- "Cleaning Single SC and FC Connectors" next
- "Cleaning Duplex SC Connectors" on page 52
- "Cleaning Receptacle or Duplex Devices" on page 53

Danger: To avoid getting debris in your eyes, wear safety glasses when working with the canned air duster.

Danger: To avoid eye irritation on contact, wear safety glasses when working with isopropyl alcohol.

Caution: To prevent further contamination, clean fiber optic equipment only when there is evidence of contamination.

Caution: To prevent contamination, make sure the optical ports of all active devices are covered with a dust cap or optical connector.

Caution: To avoid the transfer of oil or other contaminants from your fingers to the end face of the ferrule, handle connectors with care.

Before connecting them to transmission equipment, test equipment, patch panels, or other connectors, clean all fiber optic connectors. The performance of an optical fiber connector depends on how clean the connector and coupling are at the time of connection. Use the following cleaning procedures when analyzing fiber connector integrity.

If a connector performs poorly after cleaning, visually inspect the connector to determine the possible cause of the problem and to determine if it needs replacing.

Cleaning Single SC and FC Connectors

To clean single SC and FC connectors:

1. Remove dust or debris by applying canned air to the cylindrical and end-face surfaces of the connector.
2. Gently wipe the cylindrical and end-face surfaces with a pad or a wipe dampened with optical-grade isopropyl alcohol.
3. Gently wipe the cylindrical and end-face surfaces with a dry, lint-free tissue.

4 Dry the connector surfaces by applying canned air or letting them air dry.

Caution: To prevent contamination, do not touch the connector surfaces after cleaning; and cover them with dust caps if you are not going to use them right away.

Cleaning Duplex SC Connectors

To clean duplex connectors:

1 To remove or retract the shroud, do one of the following.

- On removable shroud connectors, hold the shroud on the top and bottom at the letter designation, apply medium pressure, and pull it free from the connector body. Do not discard the shroud.
- On retractable shroud connectors, hold the shroud in its retracted position.

2 Remove dust or debris from the ferrules and connector face with the canned air duster.

3 Gently wipe the cylindrical and end-face surfaces of both ferrules using a wipe saturated with optical-grade isopropyl alcohol.

4 Gently wipe the cylindrical and end-face surfaces of the connector with Texwipe cloth (or dry lint-free tissue).

5 Blow dry the connector surfaces with canned air.

6 Using care to not touch the clean ferrules, gently push the shroud back onto the connector until it seats and locks in place.

Cleaning Receptacle or Duplex Devices

Note: To avoid contamination, optical ports should only be cleaned when there is evidence of contamination or reduced performance, or during their initial installation.

To clean receptacle or duplex devices:

Warning: To prevent oil contamination, do not use commercial compressed air.

Warning: Do not allow the tube to touch the bottom of the optical port.

1. Remove dust or debris by blowing canned air into the optical port of the device using the canned air extension tube.
2. Clean the optical port by inserting a small dry swab into the receptacle and rotating it.

Note: Each cleaning wand should only be used to clean one optical port.

3. Reconnect the optical connector and check for proper function.

   If problems persist, repeat steps 1 and 2.

Glossary

attenuation

The decrease in signal strength in an optical fiber caused by absorption and scattering. Attenuation can be calculated to express

- signal loss between two points
- total signal loss of a telecommunications system or segment

attenuator

A device inserted into the electrical or optical path to lessen or weaken the signal.

bandwidth

The range of frequencies within which a fiber-optic medium or terminal device can transmit data or information.

cable

One or more optical fibers enclosed within protective covering(s) and strength members to provide mechanical and environmental protection for the optical fibers.

cable assembly

An optical-fiber cable with connectors installed on one or both ends. The general purpose of the cable assembly is to interconnect the cabling system with opto-electronic equipment at either end of the system. Cable assemblies with connectors on one end only are called pigtails. Assemblies with connectors on both ends are typically called jumpers or patch cords.

cable plant

The cable plant consists of all the optical elements such as fiber connectors and splices between a transmitter and a receiver.

CD-ROM

compact disc read-only memory

A compact disc with pre-recorded data, normally used in large database-type applications such as directory, reference, or data retrieval.

channel

A communications path or the signal sent over that path. By multiplexing several channels, voice channels can be transmitted over one optical channel.

CO

central office

A major equipment center designed to serve the communication traffic of a specific geographical area.

configuration

The relative arrangements, options, or connection pattern of a system and its subcomponent parts and objects.

configure

The process of defining an appropriate set of collaborating hardware and software objects to solve a particular problem.

CWDM

coarse wavelength division multiplexing

A technology that allows two or four optical signals with different wavelengths to be simultaneously transmitted in the same direction over one fiber, and then separated by wavelength at the distant end.

dB

decibel

A unit of measure indicating relative optic power on a logarithmic scale. Often expressed to a fixed value, such as dBm (1 milliwatt) or dBµ (1 microwatt).

dBm

decibels above one milliwatt

demultiplexing

The separating of different wavelengths in a wavelength-division multiplexing system. The opposite of multiplexing.

dispersion

The broadening of input pulses as they travel the length of an optical fiber. There are three major types of dispersion, as follows:

- modal dispersion, which is caused by the many optical path lengths in a multimode fiber
- chromatic dispersion, which is caused by the differential delay at various wavelengths in the optical fiber
- waveguide dispersion, which is caused by light traveling through both the core and cladding materials in single-mode fibers

DWDM

dense wavelength division multiplexing

A technology that allows a large number of optical signals (usually 16 or more) with different wavelengths to be simultaneously transmitted in the same direction over one fiber, and then separated by wavelength at the distant end.

ESD

electrostatic discharge

Discharge of stored static electricity that can damage electronic equipment and impair electrical circuitry, resulting in complete or intermittent failures.

Ethernet

A local area network data link protocol based on a packet frame. Ethernet, which usually operates at 10 Mbit/s, allows multiple devices to share access to the link.

facility

Any provisional configuration that provides a transmission path between two or more locations without terminating or signalling equipment. Also, the logical representation of a transport signal.

fiber

See optical fiber.

fiber loss

Also optical fiber loss. The attenuation of the light signal in optical-fiber transmission.

fiber-optic link

A combination of transmitter, receiver, and fiber-optic cable capable of transmitting data.

FO

fiber optics

The branch of optical technology dedicated to transmitting light through fibers made of transparent materials such as glass and plastic.

GBIC

Gigabit interface converter

Allows Gigabit Ethernet ports to link with fiber optic networks.

Gbit/s

Gigabits per second

A measure of the bandwidth on a data transmission medium. One Gbit/s equals 1,000,000,000 bps.

Gigabit Ethernet

Gigabit Ethernet

A LAN transmission standard that provides a data rate of one billion bits per second (Gbit/s).

ground

An electrical term meaning to connect to the earth or other large conducting body to serve as an earth thus making a complete electrical circuit.

GUI

graphical user interface

A graphical (rather than textual) interface to a computer.

hub

A group of circuits connected at one point on a network.

insertion loss

In an optical fiber system, the total optical power loss caused by insertion of an optical component, such as a connector, splice, or coupler. Usually given in dB.

kbps

thousands of bits per second

A measure of the bandwidth on a data transmission medium. One kbps equals 1000 bps.

lambda

See wavelength.

LAN

local area network

A data communications network that is geographically limited (typically to a 1 km radius), allowing easy interconnection of terminals, microprocessors, and computers within adjacent buildings. Most notable of LAN topologies are Ethernet, token ring, and FDDI.

laser

An acronym for "Light Amplification by Stimulated Emission of Radiation". A laser is a monochromatic (same wavelength), coherent (waves in phase), beam of radiation.

loss

The ratio of optical output power to input power, usually given in units of dB. Usually represents a decrease in an optical signal. A negative loss means a gain of power.

loss/attenuation

In an optical fiber, the absorption of light by molecules in the fiber, causing some of the intensity of light to be lost from the signal. Usually measured in dB.

loss budget

The amount of optical power launched into a system that will be lost through various mechanisms, such as insertion losses and fiber attenuation. Usually given in dB.

MAN

metropolitan area network

A MAN consists of LANs interconnected within a radius of approximately 80 km (50 miles). MANs typically use fiber-optic cable to connect LANs.

margin

The amount of loss, beyond the link budget amount, that can be tolerated in a link.

MMF

multimode fiber

A fiber with core diameter much larger than the wavelength of light transmitted that allows many modes of light to propagate. Commonly used with LED sources for lower speed, short distance lengths. Typical core sizes (measured in microns) are 50/125, 62.5/125 and 100/140.

mode

An independent light path through an optical fiber. *See* SMF and MMF.

multimode fiber

See MMF.

multiplexing

Carriage of multiple channels over a single transmission medium; any process by which a dedicated circuit can be shared by multiple users. Typically, data streams are interspersed on a bit or byte basis (time division), or separated by different carrier frequencies (frequency division).

MUX

multiplexer

A device that combines two or more signals into a signal composite data stream for transmission on a single channel.

NDSF

non-dispersion-shifted fiber

A type of optical fiber optimized for the 1310 nm transmission window.

nanometer

See nm.

nm

nanometer

One billionth of a meter (10^{-9} meter). A unit of measure commonly used to express the wavelengths of light.

node

A point in an optical network where optical signals can be processed and switched among various links.

NZDSF

non-zero-dispersion-shifted fiber

A type of optical fiber optimized for high bit-rate and dense wavelength-division-multiplexing applications.

OADM

optical add/drop multiplexer

An optical multiplexer/demultiplexer (mux/demux) that adds or drops one CWDM channel of the same wavelength from the optical fiber and allows all other wavelengths to pass straight through.

O/E

optical to electrical

Optical to electrical conversion.

OC

optical carrier

Series of physical protocols, such as OC-1, OC-2, and OC-3, defined for SONET optical signal transmissions. OC signal levels put STS frames onto fiber-optic line at a variety of speeds. The base rate is 51.84 Mbit/s (OC-1);

each signal level thereafter operates at a speed divisible by that number. For example, OC-3 operates at 155.52 Mbit/s.

OC-1

optical carrier - level 1

An optical SONET signal at 51.84 Mbit/s.

OC-3

optical carrier - level 3

An optical SONET signal at 155.52 Mbit/s.

OC-12

optical carrier - level 12

An optical SONET signal at 622.08 Mbit/s.

OMUX

optical multiplexer

An optical multiplexer/demultiplexer that multiplexes and demultiplexes four or eight CWDM wavelength channels from a two-fiber circuit.

optical channel

An optical wavelength band for WDM optical communications.

optical fiber

Very thin strands of pure silica glass through which laser light travels in an optical network. Consists of a core surrounded by a less refractive index cladding.

optical seam

An optical seam occurs at any site in a network when there is no optical passthrough, that is, where information is dropped from but not added onto the ring.

Optical Time Domain Reflectometer (OTDR)

Device used to inspect optical fiber links by sending optical pulses down them and monitoring the light reflected back to the device. Can calculate overall fiber attenuation and highlight points of loss in the fiber, or even fiber breaks.

optical waveguide

See optical fiber.

passive device

A device that does not require a source of energy to function.

passthrough

A signal bypass mechanism that allows the signal to pass through a device with little or no signal processing.

point-to-point transmission

Carrying a signal between two endpoints without branching to other points.

protocol

The procedure used to control the orderly exchange of information between stations on a data link or on a data-communications network or system. Protocols specify standards in three areas: the code set, usually ASCII or EBCDIC; the transmission mode, usually asynchronous or synchronous; and the non-data exchanges of information by which the two devices establish contact and control, detect failures or errors, and initiate corrective action.

provisioning

The process by which a requested service is designed, implemented, and tracked.

ring architecture

A network topology in which terminals are connected serially point-to-point in an unbroken circle.

Rx

receive

A terminal device that includes a detector and signal processing electronics. It functions as an optical-to-electrical converter.

scalable

The ability to add power and capability to an existing system without significant expense or overhead.

single-mode fiber

See SMF.

SMF

A mode is one of the various light waves that can be transmitted in an optical fiber. Each optical signal generates many different modes, but in single-mode fiber the aim is to only have one of them transmitted. This is achieved through having a core of a very small diameter (usually around 10 micrometers), with a cladding that is usually ten times the core diameter. These fibers have a potential bandwidth of 50 to 100 GHz per kilometer.

Tx

transmit

A device that includes a LED or laser source and signal conditioning electronics that is used to inject a signal into optical fiber.

U

(vertical) unit

One U is 1.75 inches. Standard equipment racks have bolt holes spaced evenly on the mounting rails to permit equipment that is sized in multiples of this vertical unit to be mounted in the same rack.

WAN

wide area network

A physical or logical network that provides data communications to a larger number of independent users than are usually served by a LAN and is usually spread over a larger geographic area than that of a LAN.

wavelength

All electromagnetic radiation (radio waves, microwaves, ultraviolet light, visible light, etc.) is transmitted in waves, and the wavelength is the distance between the successive crests of the waves. In optical networks, you can think of different wavelengths as being different colors of light. Wavelengths of light are measured in nanometers or microns.

WDM

wavelength division multiplexing

Transmitting many different colors (wavelengths) of laser light down the same optical fiber at the same time in order to increase the amount of information that can be transferred.

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